# PATENT ABSTRACTS OF JAPAN

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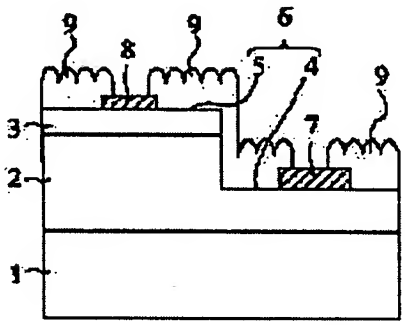
## (54) LIGHT-EMITTING DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To improve the light extraction efficiency of a light-emitting device which radiates the light emitted from a light-emitting layer to the outside and to easily manufacture the element by providing a light-scattering layer on the light-extracting surface of the light-emitting device.
SOLUTION: An n-type GaN layer 2, a p-type GaN layer 3, an n-type side-electrode forming region 4, and a p-type side-electrode forming region 5 are formed on a sapphire substrate 1, and n- and p-type side electrodes 7 and 8 are respectively formed on the n- and p-type side-electrode forming regions 4 and 5. The n- and p-type GaN layers 2 and 3 become light-emitting layers and the section from the region 5 to the region 4 becomes a light-extracting surface 6. A light-scattering layer 9, which is composed of silicon dioxide and has an uneven surface, is formed into a nearly entire region of the surface 6. Since the uneven surface is formed not only on the surface of the GaN layer, but also on the surface of the light-scattering layer 9, the machining damages to the GaN layers 2 and 3 can be prevented, and the deterioration in the light- emitting efficiency of a light-emitting device is prevented.

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CLAIMS

[Claim(s)]
[Claim 1] Luminescence equipment which is luminescence equipment made to emit the light generated in the luminous layer to the exterior through an optical ejection side, and is characterized by having a light-scattering layer on said optical ejection side.
[Claim 2] Luminescence equipment according to claim 1 characterized by said light-scattering layer having insulation.
[Claim 3] Luminescence equipment according to claim 1 or 2 characterized by said light-scattering layer having a concavo-convex front face.
[Claim 4] Luminescence equipment according to claim 3 characterized by the heights of the concavo-convex front face of said light-scattering layer consisting of a part of spherical particles.
[Claim 5] the thin film layer which said light-scattering layer covered the front face of two or more convex domains prepared on said optical ejection side at island shape, and two or more of these convex domains, and it had on said optical ejection side — since — the luminescence equipment according to claim 3 characterized by becoming.
[Claim 6] Luminescence equipment according to claim 5 characterized by said convex domain consisting of MgAl 2O4.
[Claim 7] Luminescence equipment according to claim 3 to 6 characterized by the width of face and the level difference of said irregularity being equal to the value which **(ed) wavelength of the light generated in said luminous layer by the square root of the refractive index of said light-scattering layer, or being large.
[Claim 8] two or more refraction fields where said light-scattering layer was prepared into the thin film layer and this thin film layer and which have a different refractive index from the thin film layer concerned — since — the luminescence equipment according to claim 1 or 2 characterized by becoming.
[Claim 9] said refraction field — abbreviation — the luminescence equipment according to claim 8 characterized by the spherical thing.
[Claim 10] The diameter of said refraction field is luminescence equipment according to claim 9 characterized by being equal to the value which **(ed) wavelength of the light generated in said luminous layer by the square root of the refractive index of said refraction field, or being large.
[Claim 11] Luminescence equipment according to claim 1 or 2 characterized by said light-scattering layer consisting of a thin film layer in which two or more reflective fields were established in the interior.
[Claim 12] Luminescence equipment according to claim 11 characterized by said reflective field consisting of a metal.
[Claim 13] said reflective field — abbreviation — the luminescence equipment according to claim 11 or 12 characterized by the spherical thing.
[Claim 14] The diameter of said reflective field is luminescence equipment according to claim 13 characterized by being equal to the value which **(ed) wavelength of the light generated in said luminous layer by the square root of the refractive index of said refraction field, or being large.
[Claim 15] Said luminous layer is luminescence equipment according to claim 1 to 14 characterized by consisting of a gallium nitride (GaN) system semi-conductor containing a gallium (Ga) and nitrogen (N).

[Translation done.]

## DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the luminescence equipment made to emit the light generated in the luminous layer to the exterior through an optical ejection side.
[0002]
[Description of the Prior Art] Semiconductor laser (LD) and light emitting diode (LED) using the semi-conductor as a typical thing of a light emitting device are known. Since the light to which the phase was equal is obtained, LD is applied as the light source for record regenerative apparatus, such as the light source for optical communication, and a compact disk.
[0003] On the other hand, LED has a low power and the description of being long lasting, and is used for the light source for a display, for example, the plotting board, an outdoor advertising plate, etc. of a yard. For an activity on a such application top, especially the outdoors, the high brightness LED is required.
[0004] In recent years, the application to the full color large-sized display of LED is expected very much from being developed for high brightness blue LED. However, in order to compete with the full color large-sized display which used the existing CRT method etc., the further high brightness of LED and low-power-ization are desired.
[0005] One technical means for realizing this are raising the optical ejection effectiveness to the exterior of LED. As this example, in a JP,6-291368,A (H01L33/00) number In the LED equipment which comes to form the gallium nitride (GaN) system semi-conductor layer containing a gallium (Ga) and nitrogen (N) on silicon on sapphire The approach of forming irregularity in the semi-conductor layer front face by the side of an optical ejection side is proposed by etching a front face for GaN system semi-conductor each class after crystal growth, or carrying out crystal growth of GaN system semi-conductor each class on the off substrate from C side of silicon on sapphire.

[0006] By preparing such irregularity explains using type section drawing of the LED equipment which showed the mechanism with optical increasing ejection effectiveness to drawing 7 . In addition, drawing 7 (a) shows the LED equipment with which conventional LED equipment with a flat semi-conductor front face was formed to this drawing (b) in the concavo-convex field on the semi-conductor front face again, respectively.
[0007] The n mold GaN system semi-conductor layer by which 101 were formed in the substrate among this drawing, and 102 was formed on the substrate 101, and 103 are the p mold GaN system semi-conductor layers formed on the n-type-semiconductor layer 102. Moreover, n mold lateral electrode with which 104 was formed on the side face of the n mold GaN system semi-conductor layer 102, and 105 are p mold lateral electrodes formed on the p mold GaN system semi-conductor layer 103.
[0008] Although the light which this LED equipment operated and was generated near the interface (pn junction interface) of the n-type-semiconductor layer 102 and a p type semiconductor 103 is taken out outside through optical ejection side 103a by impressing an electrical potential difference to the forward direction between these electrodes 104 and 105 Since the refractive indexes of the exterior and the semi-conductor layer 103 differ and light refracts or reflects on said optical ejection side 103a front face, a part of light cannot be taken out outside.
[0009] Moreover, among drawing 7 (a), the light generated near the interface of the n-type-semiconductor layer 102 and a p type semiconductor 103 is refracted on an optical ejection side 103a front face, and 106 are a light which advances along this front face, and call a critical angle the incident angle of the light to the optical ejection side 103a front face at this time.
[0010] In the case of the conventional LED equipment shown in drawing 7 (a), the light 107 which carried out incidence to optical ejection side 103a at the include angle deeper than this critical angle is refracted on an optical ejection side 103a front face, and is taken out outside. It was reflected on the optical ejection side 103a front face, and the light 108 which carried out incidence at the include angle shallower than a critical angle on the other hand was reflected multiply with said optical ejection side 103a front face, the interface of a substrate 101 and the semi-conductor layer 102, or the rear face of a substrate 101, and since it will be absorbed by the semi-conductor layers 102 and 103 or the substrate 101, it was not able to be taken out outside.
[0011] On the other hand, when optical ejection side 103a shown in drawing 7 (b) has irregularity, since optical ejection side 103a has irregularity, the incident angle of the light 109 to this surface 103a becomes deeper than said critical angle, and the light 108 shown in drawing 7 (a) and the light 109 which advances toward optical ejection side 103a at the almost same include angle will be taken out outside.
[0012] That is, the light 108 which cannot be taken out if the optical ejection side 103a front face is flat can be taken out by preparing irregularity in an optical ejection side 103a front face, therefore the optical ejection effectiveness to the exterior of LED equipment can be raised.
[0013]
[Problem(s) to be Solved by the Invention] However, by the approach of etching p mold GaN system semi-conductor layer surface 103a which is an optical ejection side after crystal growth about GaN system semi-conductor each class 102 and 103, since the etch rate of a GaN system semi-conductor was slow, precise processing was difficult, or the processing breakage to the crystal by etching crossed throughout the surface abbreviation for LED equipment (103a) and was introduced, the technical problem of ** that there was a possibility may cause decline in luminous efficiency occurred.
[0014] Moreover, although this irregularity is automatically formed of crystal growth by the approach of forming irregularity in optical ejection side 103a by carrying out crystal growth of GaN system semi-conductor each class on the off substrate from C side of silicon on sapphire, since it is not clear at what kind of event of this crystal growth process irregularity is formed, it is difficult [ it / the crystal growth of mum order is required for the usual LED, and ] to control the dimension. Consequently, the optical ejection effectiveness to

the exterior may fully be unable to improve.
[0015] This invention is accomplished in view of an above-mentioned trouble, and the optical ejection effectiveness to the exterior is high, and it aims at offering easily the luminescence equipment which can be manufactured with a sufficient controllability.
[0016]
[Means for Solving the Problem] The luminescence equipment of this invention is luminescence equipment made to emit the light generated in the luminous layer to the exterior through an optical ejection side, is characterized by having a light-scattering layer on said optical ejection side, and is characterized by said light-scattering layer having insulation.
[0017] Moreover, said light-scattering layer is characterized by having a concavo-convex front face.
[0018] at this time, this invention consisted of a part of particles with the spherical heights of the concavo-convex front face of said light-scattering layer — or the thin film layer which said light-scattering layer covered the front face of two or more convex domains prepared on said optical ejection side at island shape, and two or more of these convex domains, and it had on said optical ejection side — since — it is characterized by to become and said convex domain consisting of MgAl 2O4.
[0019] Furthermore, it is characterized by the width of face and the level difference of said irregularity being equal to the value which ** (ed) wavelength of the light generated in said luminous layer by the square root of the refractive index of said light-scattering layer, or being large.
[0020] Moreover, two or more refraction fields where this invention has a different refractive index from the thin film layer concerned in which said light-scattering layer was prepared into the thin film layer and this thin film layer, since — becoming — the description — carrying out — **** — said refraction field — abbreviation — it is characterized by being equal to the value which **(ed) wavelength of the light in which the diameter of said refraction field generates a spherical thing in said luminous layer further by the square root of the refractive index of said refraction field, or being large.
[0021] moreover, the thing which it is characterized by to consist of a thin film layer in which the reflective field of plurality [ this invention / layer / said / light-scattering / interior ] was established, and said reflective field consists of a metal — said reflective field — abbreviation — it is characterized by being equal to the value which **(ed) wavelength of the light in which the diameter of said reflective field generates a spherical thing in said luminous layer further by the square root of the refractive index of said refraction field, or being large.
[0022] In addition, it is characterized by consisting of a gallium nitride (GaN) system semi-conductor with which, as for this invention, said luminous layer contains a gallium (Ga) and nitrogen (N).
[0023]
[Embodiment of the Invention]
[Operation gestalt 1] drawing 1 is type section drawing of the LED luminescence equipment which consists of a GaN system semi-conductor concerning the 1st operation gestalt.
[0024] The n mold GaN layer of 3 micrometers of thickness by which one was formed in silicon on sapphire among drawing 1 , and 2 was formed on the substrate 1, the p mold GaN layer of 0.2 micrometers of thickness by which 3 was formed on the n mold GaN layer 2, and 4 so that the n mold GaN layer 2 may be exposed n mold lateral electrode formation field which it comes to remove in the predetermined location in the layer of the p mold GaN layer 3 to the n mold GaN layer 2 very much, and 5 are p mold electrode formation fields simultaneously formed of said clearance.
[0025] Here, n mold and the p mold GaN layers 2 and 3 correspond to the luminous layer of this luminescence equipment, and the field which reaches n mold electrode formation field 4 serves as the optical ejection side 6 from p mold lateral electrode formation field 5.
[0026] n mold lateral electrode which consists of Ti by which 7 was formed on n mold lateral electrode formation field 4, and 8 are p mold lateral electrodes which consist of Au and nickel which were formed on p mold lateral electrode formation field 5.
[0027] 9 is a light-scattering layer which consists of a silicon dioxide (SiO2) formed throughout the abbreviation for the optical ejection side 6, and if it is in this operation gestalt, it has the concavo-convex front face width of face and whose level difference this light-scattering layer is about 0.3 micrometers, respectively.
[0028] In addition, what is necessary is not to constitute especially the light-scattering layer 9 from an insulator layer, if it is when forming only on the electrode of one side, and just to constitute from an ingredient which has translucency, although the light-scattering layer 9 is constituted from an insulator layer of SiO2 in order to prevent the short circuit between these two electrodes 7 and 8 since the above-mentioned light-scattering layer 9 is formed ranging over n mold lateral electrode 7 and p mold lateral electrode 8 if it is in this operation gestalt.
[0029] One production process of **** luminescence equipment is briefly explained using drawing 2 . In addition, the same part as drawing 1 attaches the same sign.
[0030] first — the 1st process shown in drawing 2 (a) — the whole silicon-on-sapphire 1 top surface — the growth temperature of 1000 degrees C — MOCVD (organic metal gaseous-phase deposition) — crystal growth of the n mold GaN layer 2 of 3 micrometers of thickness and the p mold GaN layer 3 of 0.2 micrometers of thickness is carried out in this sequence by law. Here, Si and Mg are used for n mold and p mold dopant, respectively.
[0031] Next, at the 2nd process shown in drawing 2 (b), it leaves the field of the request on the p mold GaN layer 3 as a p mold lateral electrode formation field 5 with photolithography. Cl2 (chlorine) — as reactant gas — using — RIBE (reactant ion beam etching) — by law In order to remove about 2 micrometers of thickness of said p mold GaN layer 3 and the n mold GaN layer 2, and to form n mold lateral electrode formation field 4, then to activate the carrier of the p mold GaN layer 16, it heat-treats at 700 degrees C among nitrogen-gas-atmosphere mind.
[0032] Next, at the 3rd process shown in drawing 2 (c), n mold lateral electrode 7 which consists of Ti on n mold lateral electrode formation field 4, and p mold lateral electrode 8 which consists of Au and nickel on p mold lateral electrode formation field 5 are formed with vacuum deposition.
[0033] Furthermore, at the 4th process shown in drawing 2 (d), vacuum deposition of the insulator layer 9a which consists of SiO2 of 0.6 micrometers of thickness throughout the front face of said structure is carried out.
[0034] Then, at the 5th process shown in drawing 2 (e), the light-scattering layer 9 which has a concavo-convex front face is produced by forming the irregularity width of face and whose level difference are about 0.3 micrometers, respectively by the wet etching using the photolithography which used the interference exposing method for said insulator layer 9a front face, and the etchant of a fluoric acid system.
[0035] Finally, at the 6th process, the LED luminescence equipment which removes a part of p mold lateral electrode 7 and said light-scattering layer 9 of 8 upper parts in the contact to an electrode, and shows it to drawing 1 by the wet etching which used the etchant of photolithography and a fluoric acid system is obtained n mold side.
[0036] Light generates the luminescence equipment of this operation gestalt completely like usual LED equipment near the interface (pn

junction interface) of the n mold GaN layer 2 and the p mold GaN layer 3 by impressing an electrical potential difference to the forward direction between said electrode 7 and 8.
[0037] As mentioned above, with the usual luminescence equipment which does not have the light-scattering layer 9, since it is reflected in the direction of the interior of luminescence equipment in respect of [ 6 ] optical ejection, the light which carried out incidence at the include angle shallower than a critical angle to the optical ejection side 6 among the light generated near [ said ] the pn junction interface cannot be taken out to the exterior here. On the other hand, since the luminescence equipment of this operation gestalt is equipped with the light-scattering layer 9 which has a concavo-convex front face, with said usual luminescence equipment, the light which should carry out incidence at a shallow include angle will come to carry out incidence at an include angle deeper than a critical angle, and will be taken out from a critical angle outside. Consequently, the optical ejection effectiveness to the exterior can be improved with this luminescence equipment.
[0038] Moreover, since the light-scattering layer 9 with which the luminescence equipment of this operation gestalt is equipped consists of SiO2, as compared with a GaN system semi-conductor, etching processing is easy for it and it can form a concavo-convex front face with a sufficient controllability in a short time. Therefore, luminescence equipment equipped with the light-scattering layer 9 which has the concavo-convex front face which was excellent in dimensional accuracy by this invention can be manufactured easily.
[0039] Furthermore, since said concavo-convex front face is formed in light-scattering layer 9 front face instead of the front face of the GaN semi-conductor layer 3, processing breakage is not introduced into the GaN layers 2 and 3, therefore the luminous efficiency of this luminescence equipment does not fall.
[0040] In addition, the luminescence equipment of this operation gestalt can prevent the oxidation to which they are based on being made atmospheric air since the GaN layer 2 and three front faces are thoroughly covered with p mold lateral electrodes 7 and 8 and the light-scattering layer 9 n mold side, and the effectiveness that the property of luminescence equipment is stabilized is also acquired.
[0041] In addition, in order to heighten more the improvement effectiveness in optical ejection effectiveness to the exterior by said light-scattering layer 9, it is desirable that the concavo-convex width of face (t1) and the concavo-convex level difference (t2) which said light-scattering layer 9 has satisfy several 1 to the luminescence wavelength lambda of LED equipment and the refractive index n of the light-scattering layer 9.
[0042]
[Equation 1]

$$t_i \geq \lambda / (n)^{1/2} \qquad (i = 1, 2)$$

[0043] In this operation gestalt, since lambda was 0.36 micrometers, n was 1.45 and t1 and t2 were computed with 0.3 micrometers from said formula, the concavo-convex width of face and the concavo-convex level difference which said light-scattering layer 9 has were set to 0.3 micrometers.
[0044] Moreover, although SiO2 was used for the light-scattering layer 9 with this operation gestalt, other insulating materials, such as silicon nitride, may be used.
[0045] Furthermore, in ****, although LED luminescence equipment was explained, it can use for luminescence equipment what [ not only ] can use suitably also in other luminescence equipments, such as a surface emission-type laser, and consists of ingredients other than a GaN system semi-conductor but at large.
[0046] [Operation gestalt 2] drawing 3 is type section drawing of the LED luminescence equipment which consists of a GaN system semi-conductor concerning the 2nd operation gestalt. In addition, since it is only the configuration and its formation approach of a light-scattering layer, that this operation gestalt differs from the operation gestalt 1 shown in drawing 1 gives the same sign to the same part as drawing 1 , and it omits explanation.
[0047] 11 are the light-scattering layer which consists of SiO2 among drawing 3 , this light-scattering layer 11 is constituted by spherical section 11a and thin film section of about 0.15 micrometers of thickness 11b which carried out the shape of **** with a diameter of about 0.3 micrometers formed on the optical ejection side 6, and a part of above-mentioned spherical section 11a constitutes the heights of the light-scattering layer 11.
[0048] One production process of **** luminescence equipment is explained briefly.
[0049] At the 1-3rd processes of the luminescence equipment of this operation gestalt, the 1-3rd processes ( drawing 2 (a) - (c)) of one production process of having explained with the operation gestalt 1, and the same process are performed.
[0050] Next, at the 4th process, the solution which mixed the particle which particle size becomes from SiO2 which is about 0.3 micrometers is applied with a spin coat method throughout the front face of p mold lateral electrodes 7 and 8 into the coating liquid for SiO2 system coat formation (OCD by TOKYO OHKA KOGYO CO., LTD.) n mold side formed in the part on the optical ejection side 6 and this field 6.
[0051] Then, at the 5th process, the light-scattering layer 11 which has as heights the abbreviation one half of spherical section 11a which carried out the shape of **** with a diameter of about 0.3 micrometers is formed by performing baking for 30 minutes at 450 degrees C among nitrogen-gas-atmosphere mind, and evaporating the solvent in said solution.
[0052] Finally, at the 6th process, the luminescence equipment which removes a part of p mold lateral electrode 7 and said light-scattering layer 11 of 8 upper parts in the contact to an electrode, and shows it to drawing 3 by the wet etching which used the etchant of photolithography and a fluoric acid system is obtained n mold side.
[0053] Since the luminescence equipment of this operation gestalt equips a front face with the light-scattering layer 11 which has a concavo-convex front face, it can improve the optical ejection effectiveness to the exterior like the luminescence equipment of the operation gestalt 1.
[0054] Moreover, processing breakage is not introduced into the GaN layers 2 and 3, and luminous efficiency of this luminescence equipment is not reduced.
[0055] Furthermore, since oxidation of the GaN layer 2 and three front faces is prevented, it is effective in the property of luminescence equipment being stabilized.
[0056] Moreover, in this operation gestalt, since the light-scattering layer 11 is formed by applying the solvent containing the particle to which particle size was equal with a spin coat method, and baking this, concavo-convex dimensional accuracy is good. In addition, since photolithography and an etching process are not needed in order to form irregularity, manufacture is further simplified from the luminescence equipment of the operation gestalt 1.
[0057] In addition, in order to heighten more the improvement effectiveness in optical ejection effectiveness to the exterior by said

light-scattering layer 11, it is desirable that the concavo-convex width of face (t1) and the concavo-convex level difference (t2) which said light-scattering layer 11 has satisfy several 1 like the above-mentioned operation gestalt 1 to the luminescence wavelength lambda of LED equipment and the refractive index n of the light-scattering layer 9.
[0058] Moreover, although the coating liquid for SiO2 system coat formation was used for formation of the light-scattering layer 11 with this operation gestalt, the coating liquid for coat formation which consists of other ingredients, such as polyimide system resin, may be used. In addition, although spherical section 11a of the light-scattering layer 11 was made into the particle which consists of SiO2, the particle which consists of other ingredients, such as carbon (C), for example may be used.
[0059] Furthermore, in ****, although LED luminescence equipment was explained, it can use for other luminescence equipments, such as a surface emission-type laser, suitably.
[0060] In addition, this invention can be used also not only to a thing but to other luminescence equipments which consist of ingredients other than a GaN system semi-conductor.
[0061] [Operation gestalt 3] drawing 4 is type section drawing of the LED luminescence equipment which consists of a GaN system semi-conductor concerning the 3rd operation gestalt. In addition, in this drawing, the same sign is given to the same part as the operation gestalt 2 shown in drawing 3 , and explanation is omitted.
[0062] the thin film layer 21a concerned by which the thin film layer which 21a becomes from SiO2, and 21b— were prepared into this thin film layer 21a among drawing 4 — ** — it is two or more refraction fields which have a different refractive index, and if it is in this operation gestalt, it consists of diamonds. And the light-scattering layer 21 consists of said insulating-layer 21a and refraction field 21b—.
[0063] if it is in this operation gestalt here — said refraction field 21b— abbreviation — since it presupposed that it is spherical and thickness of about 0.3 micrometers and thin film layer 21a was set to about 0.6 micrometers for the diameter, refraction field 21b— is the gestalt buried in thin film layer 21a.
[0064] **** luminescence equipment is manufactured like the above-mentioned production process in the 4th process of one production process of the above-mentioned operation gestalt 2 except making small rotational speed of the spinner at the time of performing a spin coat.
[0065] Next, the mechanism whose optical ejection effectiveness improves by the light-scattering layer 21 of this operation gestalt is briefly explained using drawing 5 (a).
[0066] The refractive index of SiO2 which constitutes thin film layer 21a is 1.45, and the refractive index of the diamond which constitutes refraction field 21b— is larger than that of about 2.5 and SiO2. Therefore, when there is no light-scattering layer 21 among the light generated near the interface of the n mold GaN layer 2 and the p mold GaN layer 3, in order that incidence may be carried out to the optical ejection side 6 at an include angle shallower than a critical angle, the light which cannot be taken out outside may be refracted by refraction field 21b— as shown in drawing 5 (a) and the travelling direction of light may change, it can take out to the exterior. Consequently, the optical ejection effectiveness of LED equipment increases.
[0067] Moreover, as two or more reflective field 21b— of said refraction field 21b— which consists of metallic materials, such as aluminum, instead may be prepared and it is shown in drawing 5 (b) in this case, it is reflective field 21b. — When light reflects on a front face, the travelling direction of light changes. Consequently, since the light which cannot be taken out outside comes to be taken out by forming the light-scattering layer 21 outside when there is no light-scattering layer 21, the optical ejection effectiveness of luminescence equipment can be improved.
[0068] As mentioned above, with this luminescence equipment, processing breakage is not introduced into the GaN layers 2 and 3 except that the improvement effectiveness in optical ejection effectiveness is acquired, and luminous efficiency of luminescence equipment is not reduced.
[0069] Furthermore, since oxidation of the GaN layer 2 and three front faces is prevented, it is effective in the property of luminescence equipment being stabilized.
[0070] Moreover, in this operation gestalt, since the light-scattering layer 21 which has refraction field or reflective field 21b— by applying the solvent containing the particle to which particle size was equal with a spin coat method, and baking this is formed, the repeatability of said improvement effectiveness in optical ejection effectiveness is good. In addition, since photolithography and an etching process are not needed in order to form irregularity, manufacture is further simplified from the luminescence equipment of the operation gestalt 1.
[0071] In addition, in order to heighten more the improvement effectiveness in optical ejection effectiveness to the exterior by said light-scattering layer 21, it is the same as that of **** that it is desirable to satisfy the above-mentioned several 1 to the refractive index n of the ingredient of the refraction field of said light-scattering layer 21 or reflective field 21b— with which a diameter t constitutes the luminescence wavelength lambda of luminescence equipment and said refraction field 21b. Moreover, although the coating liquid for SiO2 system coat formation was used for formation of the light-scattering layer 21 with this operation gestalt, the coating liquid for coat formation which consists of other ingredients, such as polyimide system resin, may be used.
[0072] In addition, although refraction field 21b— of the light-scattering layer 21 was made into the particle which consists of a diamond, the particle which consists of other ingredients, such as sapphire (aluminum 2O3), may be used. However, the larger one of the refractive-index difference of the ingredient which constitutes refraction field 21b—, and the ingredient which constitutes thin film layer 21a is desirable. Moreover, refraction field 21b— may be gases, such as air instead of a solid material, or a vacuum.
[0073] Moreover, although the front face of thin film layer 21a may be a flat side, even if it has a concavo-convex front face, it is not cared about.
[0074] Furthermore, what is necessary is not to constitute it from an insulator layer, especially if there is no possibility of producing the short circuit of n mold lateral electrode 7 and p mold lateral electrode 8 as thin film layer 21a in this invention mentioned above, and just to consist of ingredients which have translucency.
[0075] In addition, in ****, although LED luminescence equipment was explained, it can use for other luminescence equipments, such as a surface emission-type laser, suitably. In addition, this invention can be used also not only to what used the GaN system semi-conductor but to other luminescence equipments.
[0076] [Operation gestalt 4] drawing 6 is type section drawing of the LED luminescence equipment which consists of a GaN system semi-conductor concerning the 4th operation gestalt. In addition, in this drawing, the same sign is given to the same part as the operation gestalt 1 shown in drawing 1 , and explanation is omitted.
[0077] Two or more area-of-base with 2 and a height of about 0.2 micrometers convex domain of about 0.1 micrometers which 31 are light-scattering layer which has irregularity on front face among drawing 6 , and this light-scattering layer 31 becomes from spinel (MgAl 2O4) formed on optical ejection side 6 at island shape 32 —, It is constituted by the thin film layer 33 as for which this convex domain 32 — becomes this convex domain 32 — from SiO2 of 0.3 micrometers of thickness formed throughout the optical ejection side 6 top

so that may be embedded.
[0078] One production process of **** LED luminescence equipment is explained briefly.
[0079] At the 1-3rd processes of this LED equipment, the 1-3rd processes ( drawing 2 (a) - (c)) of one production process of having explained with the operation gestalt 1, and the same process are performed.
[0080] Next, n mold side formed in the part on the optical ejection side 6 and this side 6 at the 4th process, Throughout the front face of p mold lateral electrodes 7 and 8, as a raw material at the growth temperature of 900 degrees C The aluminum of hydrogen chloride (HCl) gas transport (aluminum), MgAl 2O4 is grown up by the gaseous-phase epitaxial method using the magnesium chloride (MgCl2) of hydrogen (H2) gas transport, and a carbon dioxide (CO2). By this approach, MgAl 2O4 grows up to be island shape, and two or more convex domain 32 — which consists of area-of-base 2 and MgAl 2O4 with a height of about 0.2 micrometers of about 0.1 micrometers is formed.
[0081] Then, at the 5th process, the light-scattering layer 31 which has irregularity is further formed in a front face p mold lateral electrodes 7 and 8 and by carrying out vacuum deposition of the thin film layer 33 of two or more of said convex domain 32 — which consists of SiO2 of 0.3 micrometers of thickness throughout a front face n mold side formed in the part on the optical ejection side 6 and this field 6 so that said convex domain 32 — may be embedded.
[0082] Finally, at the 6th process, the luminescence equipment which removes a part of p mold lateral electrode 7 and said light-scattering layer 31 of 8 upper parts in the contact to an electrode, and shows it to drawing 6 by the wet etching which used the etchant of photolithography, a fluoric acid system, and a phosphoric acid system is obtained n mold side.
[0083] Since the luminescence equipment of this operation gestalt equips a front face with the light-scattering layer 31 which has irregularity, it can improve the optical ejection effectiveness to the exterior like the operation gestalten 1, 2, and 3.
[0084] Moreover, processing breakage is not introduced into the GaN layers 2 and 3, and luminous efficiency of this luminescence equipment is not reduced.
[0085] Furthermore, since oxidation of the GaN layer 2 and three front faces is prevented, it is effective in the property of luminescence equipment being stabilized.
[0086] Moreover, in this operation gestalt, convex domain 32— of two or more convex domain 32 — which consists of MgAl 2O4 to which the dimension was equal since the dimension was controllable by growth temperature and growth time amount can be formed. Furthermore, these convex domains 32 — n mold side formed in the part on the optical ejection side 6 and this side 6 after formation, although p mold lateral electrodes 7 and 8 and the light-scattering layer 31 of two or more of said convex domain 32 — which forms the thin film layer 33 and has irregularity on a front face throughout a front face are obtained, since the thin film layer 33 is formed with vacuum deposition, the thickness controllability is good. Therefore, the dimensional accuracy of said irregularity is good.
[0087] However, about the dimensional accuracy of said irregularity, the operation gestalt 1 is more high. On the other hand, since photolithography and an etching process are not needed about the ease of LED luminescence equipment manufacture in order to form irregularity with this operation gestalt, manufacture is further simplified from the luminescence equipment of the operation gestalt 1.
[0088] In addition, in order to heighten more the improvement effectiveness in optical ejection effectiveness to the exterior by said light-scattering layer 31, it is desirable to satisfy several 1 relation like the operation gestalten 1, 2, and 3.
[0089] Moreover, other ingredients may be used for said convex domain 32 —, although island-shape growth of MgAl 2O4 was used with this operation gestalt in order to prepare irregularity in the front face of the light-scattering layer 31. In addition, although SiO2 was used for the wrap film 33 for said convex domain 32 —, other insulating materials, such as silicon nitride, may be used, or not only an insulating material but other translucency ingredients may be used.
[0090] Furthermore, in ****, although LED luminescence equipment was explained, it can use for other luminescence equipments, such as a surface emission-type laser, suitably.
[0091] In addition, this invention consists of ingredients other than a GaN system semi-conductor, or can be used also about the luminescence equipment which does not use a semiconductor material.
[0092]
[Effect of the Invention] The luminescence equipment of this invention is luminescence equipment which makes emit to the exterior the light generated in the luminous layer through an optical ejection side, since it is equipped with a light-scattering layer on said optical ejection side, it is conventionally reflected in the direction of the interior of luminescence equipment in respect of optical ejection, and becomes possible [ taking out effectively the light which was not able to take out to the exterior outside ], and can offer the luminescence equipment whose optical ejection effectiveness to the exterior improved.

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[Translation done.]

## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is type section drawing of the luminescence equipment concerning the 1st operation gestalt of this invention.
[Drawing 2] It is type section drawing classified by process showing one production process of the luminescence equipment concerning the operation gestalt of the above 1st.
[Drawing 3] It is type section drawing of the luminescence equipment concerning the 2nd operation gestalt of this invention.
[Drawing 4] It is type section drawing of the luminescence equipment concerning the 3rd operation gestalt of this invention.
[Drawing 5] It is type section drawing of the luminescence equipment for explaining a mechanism with optical ejection effectiveness increasing in the 3rd operation gestalt of this invention.
[Drawing 6] It is type section drawing of the luminescence equipment concerning the 4th operation gestalt of this invention.
[Drawing 7] It is type section drawing of the LED luminescence equipment at the time of the optical refraction in an optical ejection side, and the equipment actuation which shows a reflective situation.
[Description of Notations]
2 N Mold GaN Layer (Luminous Layer)
3 P Mold GaN Layer (Luminous Layer)
4 N Mold Lateral Electrode Formation Field
5 P Mold Lateral Electrode Formation Field
6 Optical Ejection Side
9 Light-Scattering Layer

[Translation done.]

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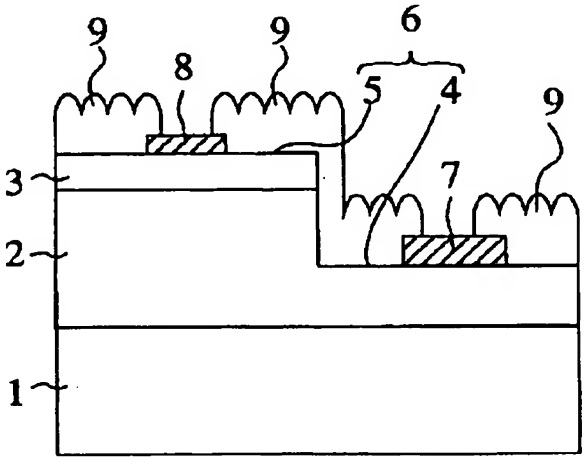
(54)【発明の名称】　発光装置

(57)【要約】
【課題】　外部への光取り出し効率が高く、且つ、制御性良く容易に製造可能な発光装置を提供する。
【解決手段】　発光層２、３で発生した光を光取り出し面６を通して外部へ放射させる発光装置であって、前記光取り出し面６上に、光散乱層９を備える。



【特許請求の範囲】
【請求項１】　発光層で発生した光を光取り出し面を通して外部へ放射させる発光装置であって、前記光取り出し面上に、光散乱層を備えることを特徴とする発光装置。
【請求項２】　前記光散乱層が絶縁性を有することを特徴とする請求項１記載の発光装置。
【請求項３】　前記光散乱層が凹凸表面を有することを特徴とする請求項１または２記載の発光装置。
【請求項４】　前記光散乱層の凹凸表面の凸部が、球状の粒子の一部から構成されたことを特徴とする請求項３記載の発光装置。
【請求項５】　前記光散乱層は、前記光取り出し面上に島状に設けられた複数個の凸領域と、該複数個の凸領域の表面を覆って前記光取り出し面上に備えられた薄膜層と、からなることを特徴とする請求項３記載の発光装置。
【請求項６】　前記凸領域が$MgAl_2O_4$からなることを特徴とする請求項５記載の発光装置。
【請求項７】　前記凹凸の幅及び段差が、前記発光層で発生する光の波長を前記光散乱層の屈折率の平方根で除した値に等しいか、あるいは大きいことを特徴とする請求項３乃至６記載の発光装置。
【請求項８】　前記光散乱層が、薄膜層と、該薄膜層中に設けられた、当該薄膜層と異なる屈折率を有する複数の屈折領域と、からなることを特徴とする請求項１または２記載の発光装置。
【請求項９】　前記屈折領域が略球状であることを特徴とする請求項８記載の発光装置。
【請求項１０】　前記屈折領域の直径は、前記発光層で発生する光の波長を前記屈折領域の屈折率の平方根で除した値に等しいか、あるいは大きいことを特徴とする請求項９記載の発光装置。
【請求項１１】　前記光散乱層が、内部に複数の反射領域が設けられた薄膜層からなることを特徴とする請求項１または２記載の発光装置。
【請求項１２】　前記反射領域が金属からなることを特徴とする請求項１１記載の発光装置。
【請求項１３】　前記反射領域が略球状であることを特徴とする請求項１１または１２記載の発光装置。
【請求項１４】　前記反射領域の直径は、前記発光層で発生する光の波長を前記屈折領域の屈折率の平方根で除した値に等しいか、あるいは大きいことを特徴とする請求項１３記載の発光装置。
【請求項１５】　前記発光層は、ガリウム（Ｇａ）と窒素（Ｎ）を含む窒化ガリウム（ＧａＮ）系半導体からなることを特徴とする請求項１乃至１４記載の発光装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、発光層で発生した光を光取り出し面を通して外部へ放射させる発光装置に関する。
【０００２】
【従来の技術】発光素子の代表的なものとしては、半導体を用いた半導体レーザ（ＬＤ）や発光ダイオード（ＬＥＤ）が知られている。ＬＤは、位相の揃った光が得られることから、光通信用の光源やコンパクトディスク等の記録再生装置用の光源として応用されている。
【０００３】一方、ＬＥＤは、低消費電力、長寿命という特徴を有し、表示用光源、例えば駅構内の表示板や屋外広告板等に使用されている。このような応用上、特に屋外での使用のためには、高輝度ＬＥＤが必要である。
【０００４】近年、高輝度青色ＬＥＤが開発されるに至って、ＬＥＤのフルカラー大型ディスプレイへの応用が期待されている。しかしながら、既存のＣＲＴ方式等を用いたフルカラー大型ディスプレイと競合するために、ＬＥＤの更なる高輝度、低消費電力化が望まれる。
【０００５】これを実現するための一つの技術的手段は、ＬＥＤの外部への光取り出し効率を高めることである。この例として、特開平６－２９１３６８（Ｈ０１Ｌ３３／００）号には、サファイア基板上にガリウム（Ｇａ）と窒素（Ｎ）を含む窒化ガリウム（ＧａＮ）系半導体層を形成してなるＬＥＤ装置において、ＧａＮ系半導体各層を結晶成長後に表面をエッチングするか、あるいは、サファイア基板のＣ面からのオフ基板上にＧａＮ系半導体各層を結晶成長することにより、光取り出し面側の半導体層表面に凹凸を形成する方法が提案されている。
【０００６】このような凹凸を設けることにより、光取り出し効率が高まるメカニズムを、図７に示したＬＥＤ装置の模式断面図を用いて説明する。尚、図７（ａ）は半導体表面が平坦な従来のＬＥＤ装置を、また同図（ｂ）は半導体表面に凹凸面が設けられたＬＥＤ装置をそれぞれ示している。
【０００７】同図中、１０１は基板、１０２は基板１０１上に形成されたｎ型ＧａＮ系半導体層、１０３はｎ型半導体層１０２上に形成されたｐ型ＧａＮ系半導体層である。また、１０４はｎ型ＧａＮ系半導体層１０２の側面上に形成されたｎ型側電極、１０５はｐ型ＧａＮ系半導体層１０３上に形成されたｐ型側電極である。
【０００８】これらの電極１０４、１０５間の順方向に電圧を印加することにより、このＬＥＤ装置は動作し、ｎ型半導体層１０２とｐ型半導体１０３との界面（ｐｎ接合界面）近傍で発生した光が光取り出し面１０３ａを通して外部に取り出されるが、外部と半導体層１０３の屈折率が異なるために、前記光取り出し面１０３ａ表面上で光が屈折あるいは反射するため、一部の光は外部に取り出すことができない。
【０００９】また、図７（ａ）中、１０６はｎ型半導体層１０２とｐ型半導体１０３との界面近傍で発生した光

が光取り出し面１０３ａ表面上で屈折し、該表面に沿って進行する光であり、この時の光取り出し面１０３ａ表面に対する光の入射角を臨界角と呼ぶ。

【００１０】図７（ａ）に示した従来のＬＥＤ装置の場合には、この臨界角より深い角度で光取り出し面１０３ａに入射した光１０７は、光取り出し面１０３ａ表面で屈折し、外部へ取り出される。一方、臨界角より浅い角度で入射した光１０８は光取り出し面１０３ａ表面で反射され、前記光取り出し面１０３ａ表面、基板１０１と半導体層１０２との界面、あるいは、基板１０１の裏面で多重反射し、半導体層１０２、１０３、あるいは、基板１０１により吸収されてしまうために外部に取り出すことができなかった。

【００１１】これに対し、図７（ｂ）に示した光取り出し面１０３ａが凹凸を有する場合には、図７（ａ）に示した光１０８とほぼ同じ角度で光取り出し面１０３ａに向かって進行する光１０９は、光取り出し面１０３ａが凹凸を有するために、該表面１０３ａに対する光１０９の入射角が前記臨界角より深くなり、外部に取り出されることとなる。

【００１２】即ち、光取り出し面１０３ａ表面が平坦であれば取り出すことができない光１０８を、光取り出し面１０３ａ表面に凹凸を設けることにより取り出すことができる、従ってＬＥＤ装置の外部への光取り出し効率を高めることができるのである。

【００１３】

【発明が解決しようとする課題】しかしながら、ＧａＮ系半導体各層１０２、１０３を結晶成長後に光取り出し面であるｐ型ＧａＮ系半導体層表面１０３ａをエッチングする方法では、ＧａＮ系半導体のエッチング速度が遅く、精密な加工が困難である、あるいは、エッチングによる結晶への加工損傷がＬＥＤ装置の表面略全域（１０３ａ）に渡って導入されるため発光効率の低下を招く恐れがある、等の課題があった。

【００１４】また、サファイア基板のＣ面からのオフ基板上にＧａＮ系半導体各層を結晶成長することにより、光取り出し面１０３ａに凹凸を形成する方法では、該凹凸は結晶成長により自然に形成されるが、通常のＬＥＤにはμｍオーダーの結晶成長が必要であり、該結晶成長過程のいかなる時点で凹凸が形成されるかが明らかでないので、その寸法を制御することが困難である。この結果、外部への光取り出し効率が十分に向上できない可能性があった。

【００１５】本発明は、上述の問題点を鑑み成されたものであり、外部への光取り出し効率が高く、且つ、制御性良く容易に製造可能な発光装置を提供することを目的とする。

【００１６】

【課題を解決するための手段】本発明の発光装置は、発光層で発生した光を光取り出し面を通して外部へ放射させる発光装置であって、前記光取り出し面上に、光散乱層を備えることを特徴としており、前記光散乱層が絶縁性を有することを特徴としている。

【００１７】また、前記光散乱層が凹凸表面を有することを特徴としている。

【００１８】この時、本発明は前記光散乱層の凹凸表面の凸部が、球状の粒子の一部から構成されたことを、或いは前記光散乱層は、前記光取り出し面上に島状に設けられた複数個の凸領域と、該複数個の凸領域の表面を覆って前記光取り出し面上に備えられた薄膜層と、からなること、前記凸領域が$MgAl_2O_4$からなることを特徴としている。

【００１９】さらには、前記凹凸の幅及び段差が、前記発光層で発生する光の波長を前記光散乱層の屈折率の平方根で除した値に等しいか、あるいは大きいことを特徴としている。

【００２０】また、本発明は、前記光散乱層が、薄膜層と、該薄膜層中に設けられた、当該薄膜層と異なる屈折率を有する複数の屈折領域と、からなることを特徴としており、前記屈折領域が略球状であることを、さらには前記屈折領域の直径は、前記発光層で発生する光の波長を前記屈折領域の屈折率の平方根で除した値に等しいか、あるいは大きいことを特徴としている。

【００２１】また、本発明は、前記光散乱層が、内部に複数の反射領域が設けられた薄膜層からなることを特徴としており、前記反射領域が金属からなることを、前記反射領域が略球状であることを、さらには前記反射領域の直径は、前記発光層で発生する光の波長を前記屈折領域の屈折率の平方根で除した値に等しいか、あるいは大きいことを特徴としている。

【００２２】加えて，本発明は、前記発光層が、ガリウム（Ｇａ）と窒素（Ｎ）を含む窒化ガリウム（ＧａＮ）系半導体からなることを特徴としている。

【００２３】

【発明の実施の形態】

［実施形態１］図１は、第１の実施形態に係わるＧａＮ系半導体からなるＬＥＤ発光装置の模式断面図である。

【００２４】図１中、１はサファイア基板、２は基板１上に形成された層厚３μｍのｎ型ＧａＮ層、３はｎ型ＧａＮ層２上に形成された層厚０．２μｍのｐ型ＧａＮ層、４はｎ型ＧａＮ層２が露出するように、ｐ型ＧａＮ層３からｎ型ＧａＮ層２の層中の所定位置に至って除去されてなるｎ型側電極形成領域、及び、５は前記除去により同時に形成されるｐ型電極形成領域である。

【００２５】ここで、ｎ型及びｐ型ＧａＮ層２及び３が本発光装置の発光層に対応し、ｐ型側電極形成領域５からｎ型電極形成領域４に至る領域が光取り出し面６となる。

【００２６】７はｎ型側電極形成領域４上に形成されたＴｉからなるｎ型側電極、８はｐ型側電極形成領域５上

に形成されたAuとNiからなるp型側電極である。

【0027】9は光取り出し面6の略全域に形成された二酸化珪素（$SiO_2$）からなる光散乱層であり、本実施形態にあっては該光散乱層が、幅及び段差がそれぞれ約0．3μmの凹凸表面を有している。

【0028】尚、本実施形態にあっては上記光散乱層9をn型側電極7及びp型側電極8に跨って形成しているので、これら両電極7及び8間の短絡を防止するために光散乱層9を$SiO_2$の絶縁膜から構成しているが、片側の電極上にのみ形成する場合にあっては光散乱層9を特に絶縁膜から構成する必要はなく、透光性を有する材料から構成すればよい。

【0029】斯る発光装置の一製造工程を図2を用いて簡単に説明する。尚、図1と同じ部分は、同一の符号を付す。

【0030】まず、図2（a）に示す第1工程では、サファイア基板1上全面に成長温度1000℃にてMOCVD（有機金属気相堆積）法により、層厚3μmのn型GaN層2、層厚0．2μmのp型GaN層3をこの順序で結晶成長する。ここで、n型及びp型ドーパントには、それぞれ、Si及びMgを用いる。

【0031】次に、図2（b）に示す第2工程では、フォトリソグラフィーによりp型GaN層3上の所望の領域をp型側電極形成領域5として残して、$Cl_2$（塩素）を反応性ガスとして用いて、RIBE（反応性イオンビームエッチング）法により、前記p型GaN層3とn型GaN層2の層厚約2μmを除去し、n型側電極形成領域4を形成し、続いて、p型GaN層16のキャリアを活性化するために、窒素ガス雰囲気中700℃にて熱処理を行う。

【0032】次に、図2（c）に示す第3工程では、n型側電極形成領域4上にTiからなるn型側電極7、p型側電極形成領域5上にAuとNiからなるp型側電極8を真空蒸着にて形成する。

【0033】更に、図2（d）に示す第4工程では、前記構造の表面全域に層厚0．6μmの$SiO_2$からなる絶縁膜9aを真空蒸着する。

【0034】その後、図2（e）に示す第5工程では、前記絶縁膜9a表面に、干渉露光法を用いたフォトリソグラフィーと、フッ酸系のエッチャントを用いたウェットエッチングにより、幅及び段差がそれぞれ約0．3μmの凹凸を形成することにより、凹凸表面を有する光散乱層9を作製する。

【0035】最後に、第6工程では、n型側、p型側電極7、8上方の前記光散乱層9の一部を、フォトリソグラフィーとフッ酸系のエッチャントを用いたウェットエッチングにより、電極へのコンタクト用に除去して、図1に示すLED発光装置が得られる。

【0036】本実施形態の発光装置は、通常のLED装置と全く同様にして、前記電極7、8間の順方向に電圧を印加することにより、n型GaN層2とp型GaN層3との界面（pn接合界面）近傍で光が発生する。

【0037】ここで上述のように、光散乱層9を有さない通常の発光装置では、前記pn接合界面近傍で発生した光の内、光取り出し面6に対して臨界角より浅い角度で入射した光は、光取り出し面6で発光装置内部方向へ反射されるため、外部へ取り出すことができない。これに対し、本実施形態の発光装置は凹凸表面を有する光散乱層9を備えるので、前記通常の発光装置では臨界角より浅い角度で入射するはずの光が、臨界角より深い角度で入射するようになり、外部へ取り出されることとなる。この結果、本発光装置では、外部への光取り出し効率を向上することができる。

【0038】また、本実施形態の発光装置が備える光散乱層9は、$SiO_2$からなるのでGaN系半導体に比して、エッチング加工が容易であり、凹凸表面を短時間で制御性良く形成できる。従って、本発明により、寸法精度の優れた凹凸表面を有する光散乱層9を備えた発光装置を容易に製造できる。

【0039】更に、前記凹凸表面は、GaN半導体層3の表面ではなく、光散乱層9表面に形成するので、GaN層2，3に加工損傷を導入することがなく、従って、本発光装置の発光効率が低下することがない。

【0040】加えて、本実施形態の発光装置は、GaN層2、3表面が、n型側、p型側電極7、8、及び光散乱層9により完全に覆われているので、大気にされることに因る酸化を防止でき、発光装置の特性が安定化される効果も得られる。

【0041】尚、前記光散乱層9による外部への光取り出し効率向上効果をより高めるためには、前記光散乱層9が有する凹凸の幅（$t_1$）及び段差（$t_2$）が、LED装置の発光波長λ及び光散乱層9の屈折率nに対して、数1を満足することが好ましい。

【0042】

【数1】

$$t_i \geq \lambda / (n)^{1/2} \qquad (i = 1, 2)$$

【0043】本実施形態においては、λが0．36μm、nが1．45であるので、$t_1$及び$t_2$は前記式より0．3μmと算出されるので、前記光散乱層9が有する凹凸の幅及び段差を0．3μmとした。

【0044】また、本実施形態では光散乱層9に、$SiO_2$を用いたが、窒化珪素等の他の絶縁物を用いても良い。

【0045】更に、上述では、LED発光装置について説明したが、面発光レーザ等の他の発光装置においても適宜用いることができ、また、GaN系半導体以外の材料からなるものに限らず、発光装置全般に用いることができる。

【００４６】［実施形態２］図３は、第２の実施形態に係わるＧａＮ系半導体からなるＬＥＤ発光装置の模式断面図である。尚、本実施形態が図１に示した実施形態１と異なるのは、光散乱層の形状、及びその形成方法のみであるので、図１と同じ部分には同一の符号を付して説明を割愛する。

【００４７】図３中、１１が$SiO_2$からなる光散乱層であり、該光散乱層１１は光取り出し面６上に形成された直径約０．３μｍの略球状をした球状部１１ａと膜厚約０．１５μｍの薄膜部１１ｂにより構成されており、上記球状部１１ａの一部が光散乱層１１の凸部を構成している。

【００４８】斯る発光装置の一製造工程を簡単に説明する。

【００４９】本実施形態の発光装置の第１～３工程では、実施形態１で説明した一製造工程の第１～３工程（図２（ａ）～（ｃ））と同様の工程を行う。

【００５０】次に、第４工程では、光取り出し面６上、及び、該面６上の一部に形成されたｎ型側、ｐ型側電極７、８の表面全域に、$SiO_2$系被膜形成用塗布液（東京応化工業社製ＯＣＤ）中に粒径が約０．３μｍの$SiO_2$からなる粒子を混合した溶液を、スピンコート法にて塗布する。

【００５１】その後、第５工程では、窒素ガス雰囲気中４５０℃にて３０分間ベーキングを行い、前記溶液中の溶媒を蒸発させることにより、直径約０．３μｍの略球状をした球状部１１ａの略半分を凸部として有する光散乱層１１を形成する。

【００５２】最後に、第６工程では、ｎ型側、ｐ型側電極７、８上方の前記光散乱層１１の一部を、フォトリソグラフィーとフッ酸系のエッチャントを用いたウェットエッチングにより、電極へのコンタクト用に除去して、図３に示す発光装置が得られる。

【００５３】本実施形態の発光装置は、表面に凹凸表面を有する光散乱層１１を備えるので、実施形態１の発光装置と同様に、外部への光取り出し効率を向上することができる。

【００５４】また、ＧａＮ層２、３に加工損傷を導入することがなく、本発光装置の発光効率を低下させることがない。

【００５５】更に、ＧａＮ層２、３表面の酸化が防止されるので、発光装置の特性が安定化される効果がある。

【００５６】また、本実施形態においては、粒径の揃った粒子を含有する溶媒をスピンコート法により塗布し、これをベーキングすることで光散乱層１１を形成するので、凹凸の寸法精度は良好である。これに加えて、凹凸を形成するためにフォトリソグラフィーとエッチング工程を必要としないので、実施形態１の発光装置より更に製造が簡略化される。

【００５７】尚、前記光散乱層１１による外部への光取り出し効率向上効果をより高めるためには、前記光散乱層１１が有する凹凸の幅（$t_1$）及び段差（$t_2$）が、ＬＥＤ装置の発光波長λ及び光散乱層９の屈折率ｎに対して、前述の実施形態１と同様数１を満足することが好ましい。

【００５８】また、本実施形態では光散乱層１１の形成に$SiO_2$系被膜形成用塗布液を用いたが、ポリイミド系樹脂等の他の材料からなる被膜形成用塗布液を用いても良い。加えて、光散乱層１１の球状部１１ａを、$SiO_2$からなる粒子としたが、例えば炭素（Ｃ）等の他の材料からなる粒子を用いても良い。

【００５９】更に、上述では、ＬＥＤ発光装置について説明したが、面発光レーザ等の他の発光装置に適宜用いることができる。

【００６０】加えて、本発明は、ＧａＮ系半導体以外の材料からなるものに限らず、他の発光装置に対しても用いることができる。

【００６１】［実施形態３］図４は、第３の実施形態に係わるＧａＮ系半導体からなるＬＥＤ発光装置の模式断面図である。尚、同図において、図３に示した実施形態２と同じ部分には同一の符号を付して説明を割愛する。

【００６２】図４中、２１ａは$SiO_2$からなる薄膜層、２１ｂ…は該薄膜層２１ａ中に設けられた、当該薄膜層２１ａとと異なる屈折率を有する複数の屈折領域であり、本実施形態にあってはダイヤモンドから構成されている。そして、前記絶縁層２１ａ及び屈折領域２１ｂ…から光散乱層２１が構成されている。

【００６３】ここで、本実施形態にあっては前記屈折領域２１ｂ…を略球状とし、その直径を約０．３μｍ、また薄膜層２１ａの膜厚を約０．６μｍとしたので、屈折領域２１ｂ…は薄膜層２１ａに埋没した形態となっている。

【００６４】斯る発光装置は、上述の実施形態２の一製造工程の第４工程において、スピンコートを行う際のスピンナーの回転速度を小さくする以外は、上記製造工程と同様にして製造される。

【００６５】次に、本実施形態の光散乱層２１により光取り出し効率が向上するメカニズムを図５（ａ）を用いて簡単に説明する。

【００６６】薄膜層２１ａを構成する$SiO_2$の屈折率は１．４５であり、屈折領域２１ｂ…を構成するダイヤモンドの屈折率は約２．５と$SiO_2$のそれより大きい。従って、ｎ型ＧａＮ層２とｐ型ＧａＮ層３との界面近傍で発生した光の内、光散乱層２１が無い場合には臨界角より浅い角度で光取り出し面６に入射し、外部に取り出すことができない光が、図５（ａ）に示すように屈折領域２１ｂ…で屈折され光の進行方向が変わるために、外部へ取り出すことができるようになる。この結果、ＬＥＤ装置の光取り出し効率が高まる。

【００６７】また、前記屈折領域２１ｂ…の代わりにＡ

１等の金属材料からなる複数の反射領域２１ｂ…を設けてもよく、この場合には、図５（ｂ）に示すように、反射領域２１ｂ…表面で光が反射することにより、光の進行方向が変わる。この結果、光散乱層２１が無い場合には外部に取り出すことができない光が、光散乱層２１を設けることにより外部へ取り出されるようになるので、発光装置の光取り出し効率を向上することができる。

【００６８】以上のように、本発光装置では光取り出し効率向上効果が得られる他に、ＧａＮ層２、３に加工損傷を導入することがなく、発光装置の発光効率を低下させることがない。

【００６９】更に、ＧａＮ層２、３表面の酸化が防止されるので、発光装置の特性が安定化される効果がある。

【００７０】また、本実施形態においては、粒径の揃った粒子を含有する溶媒をスピンコート法により塗布し、これをベーキングすることで屈折領域或いは反射領域２１ｂ…を有する光散乱層２１を形成するので、前記光取り出し効率向上効果の再現性は良好である。これに加えて、凹凸を形成するためにフォトリソグラフィーとエッチング工程を必要としないので、実施形態１の発光装置より更に製造が簡略化される。

【００７１】尚、前記光散乱層２１による外部への光取り出し効率向上効果をより高めるためには、前記光散乱層２１の屈折領域或いは反射領域２１ｂ…の直径ｔが、発光装置の発光波長λ及び前記屈折領域２１ｂを構成する材料の屈折率ｎに対して前述の数１を満足することが好ましいことは、上述と同様である。また、本実施形態では光散乱層２１の形成に$SiO_2$系被膜形成用塗布液を用いたが、ポリイミド系樹脂等の他の材料からなる被膜形成用塗布液を用いても良い。

【００７２】加えて、光散乱層２１の屈折領域２１ｂ…を、ダイヤモンドからなる粒子としたが、サファイア（$Al_2O_3$）等の他の材料からなる粒子を用いても良い。但し、屈折領域２１ｂ…を構成する材料と薄膜層２１ａを構成する材料との屈折率差は大きい方が好ましい。また、屈折領域２１ｂ…は、固体材料ではなく空気等の気体、或いは、真空であっても良い。

【００７３】また、薄膜層２１ａの表面は、平坦面であっても良いが、凹凸表面を有するものであっても構わない。

【００７４】更に、本発明における薄膜層２１ａは、前述した通りｎ型側電極７とｐ型側電極８との短絡を生じさせる恐れがなければ特に絶縁膜から構成する必要はなく、透光性を有する材料から構成すれば良い。

【００７５】加えて、上述では、ＬＥＤ発光装置について説明したが、面発光レーザ等の他の発光装置に適宜用いることができる。加えて、本発明は、ＧａＮ系半導体を用いたものに限らず、他の発光装置に対しても用いることができる。

【００７６】［実施形態４］図６は、第４の実施形態に係わるＧａＮ系半導体からなるＬＥＤ発光装置の模式断面図である。尚、同図において、図１に示した実施形態１と同じ部分には同一の符号を付して説明を割愛する。

【００７７】図６中、３１が表面に凹凸を有する光散乱層であり、該光散乱層３１は光取り出し面６上に島状に形成されたスピネル（$MgAl_2O_4$）からなる底面積約０．１$\mu m^2$、高さ約０．２$\mu$ｍの複数の凸領域３２…と、該凸領域３２…が埋め込まれるように該凸領域３２…と光取り出し面６上全域に形成された膜厚０．３$\mu$ｍの$SiO_2$からなる薄膜層３３により構成されている。

【００７８】斯るＬＥＤ発光装置の一製造工程を簡単に説明する。

【００７９】本ＬＥＤ装置の第１～３工程では、実施形態１で説明した一製造工程の第１～３工程（図２（ａ）～（ｃ））と同様の工程を行う。

【００８０】次に、第４工程では、光取り出し面６上、及び、該面６上の一部に形成されたｎ型側、ｐ型側電極７、８の表面全域に、成長温度９００℃にて、原料として塩化水素（ＨＣｌ）ガス輸送のアルミニウム（Ａｌ）、水素（$H_2$）ガス輸送の塩化マグネシウム（$MgCl_2$）、及び二酸化炭素（$CO_2$）を用いた気相エピタキシャル法により、$MgAl_2O_4$を成長する。この方法では、$MgAl_2O_4$が島状に成長し、底面積約０．１$\mu m^2$、高さ約０．２$\mu$ｍの$MgAl_2O_4$からなる複数の凸領域３２…が形成される。

【００８１】その後、第５工程では、前記凸領域３２…が埋め込まれるように、光取り出し面６上、及び、該面６上の一部に形成されたｎ型側、ｐ型側電極７、８、更には前記複数の凸領域３２…の表面全域に、膜厚０．３$\mu$ｍの$SiO_2$からなる薄膜層３３を真空蒸着することによって、表面に凹凸を有する光散乱層３１を形成する。

【００８２】最後に、第６工程では、ｎ型側、ｐ型側電極７、８上方の前記光散乱層３１の一部を、フォトリソグラフィーとフッ酸系及び燐酸系のエッチャントを用いたウェットエッチングにより、電極へのコンタクト用に除去して、図６に示す発光装置が得られる。

【００８３】本実施形態の発光装置は、表面に凹凸を有する光散乱層３１を備えるので、実施形態１、２、及び３と同様に、外部への光取り出し効率を向上することができる。

【００８４】また、ＧａＮ層２、３に加工損傷を導入することがなく、本発光装置の発光効率を低下させることがない。

【００８５】更に、ＧａＮ層２、３表面の酸化が防止されるので、発光装置の特性が安定化される効果がある。

【００８６】また、本実施形態においては、$MgAl_2O_4$からなる複数の凸領域３２…の寸法を成長温度と成長時間で制御できるので、寸法の揃った凸領域３２…を形成できる。更に、これらの凸領域３２…形成後に、光

取り出し面６上、該面６上の一部に形成されたｎ型側、ｐ型側電極７、８、及び前記複数の凸領域３２…の表面全域に、薄膜層３３を形成して、表面に凹凸を有する光散乱層３１が得られるが、薄膜層３３は真空蒸着により形成するので、その膜厚制御性は良好である。従って、前記凹凸の寸法精度は良好である。

【００８７】但し、前記凹凸の寸法精度に関しては、実施形態１がより高い。一方、ＬＥＤ発光装置製造の容易さに関しては、本実施形態では凹凸を形成するためにフォトリソグラフィーとエッチング工程を必要としないので、実施形態１の発光装置より更に製造が簡略化される。

【００８８】尚、前記光散乱層３１による外部への光取り出し効率向上効果をより高めるためには、実施形態１、２、及び３と同様数１関係を満足することが好ましい。

【００８９】また、本実施形態では光散乱層３１の表面に凹凸を設けるために、$MgAl_2O_4$の島状成長を利用したが、前記凸領域３２…には他の材料を用いても良い。加えて、前記凸領域３２…を覆う膜３３には$SiO_2$を用いたが、窒化珪素等の他の絶縁物を用いても良いし、或いは絶縁物に限らず他の透光性材料を用いてもよい。

【００９０】更に、上述では、ＬＥＤ発光装置について説明したが、面発光レーザ等の他の発光装置に適宜用いることができる。

【００９１】加えて、本発明は、ＧａＮ系半導体以外の材料からなる、或いは半導体材料を用いない発光装置についても用いることができる。

【００９２】

【発明の効果】本発明の発光装置は、発光層で発生した光を光取り出し面を通して外部へ放射させる発光装置であって、前記光取り出し面上に光散乱層を備えているので、従来は光取り出し面で発光装置内部方向へ反射され、外部へ取り出すことができなかった光を有効に外部に取り出すことが可能となり、外部への光取り出し効率が向上した発光装置を提供できる。

【図面の簡単な説明】

【図１】本発明の第１の実施形態に係わる発光装置の模式断面図である。

【図２】上記第１の実施形態に係わる発光装置の一製造工程を示す工程別模式断面図である。

【図３】本発明の第２の実施形態に係わる発光装置の模式断面図である。

【図４】本発明の第３の実施形態に係わる発光装置の模式断面図である。

【図５】本発明の第３の実施形態において光取り出し効率が高まるメカニズムを説明するための発光装置の模式断面図である。

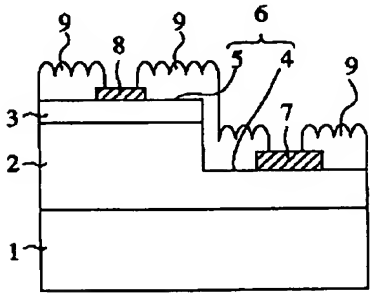
【図６】本発明の第４の実施形態に係わる発光装置の模式断面図である。

【図７】光取り出し面における光の屈折、反射の様子を示す装置動作時のＬＥＤ発光装置の模式断面図である。

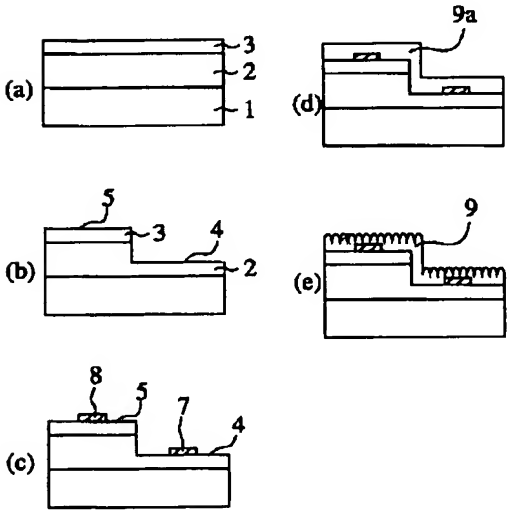
【符号の説明】

２　ｎ型ＧａＮ層（発光層）
３　ｐ型ＧａＮ層（発光層）
４　ｎ型側電極形成領域
５　ｐ型側電極形成領域
６　光取り出し面
９　光散乱層

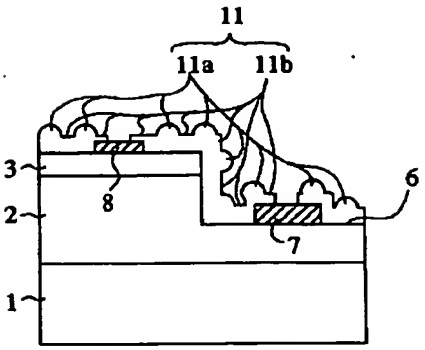
【図１】



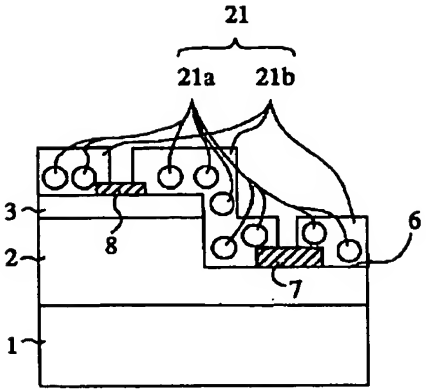

【図２】



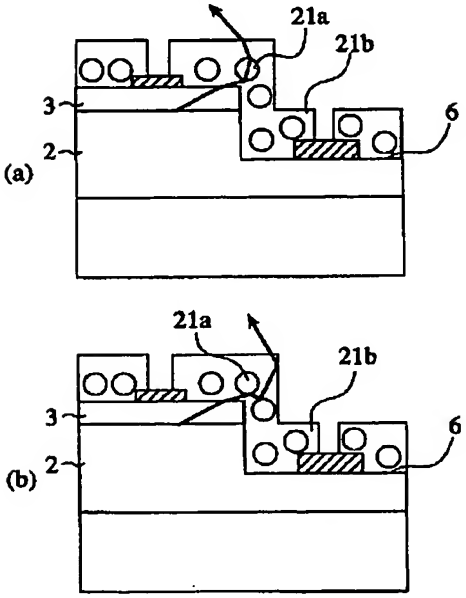
【図3】


11
11a
11b
3
2
1
8
7
6

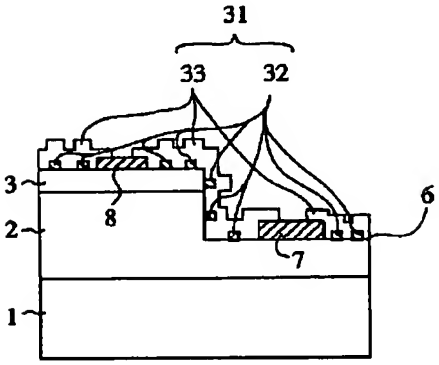
【図4】


21
21a
21b
3
2
1
8
7
6

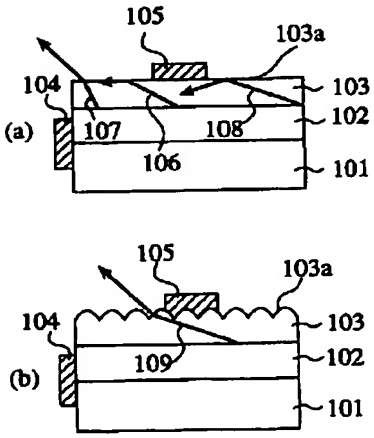
【図5】


21a
21b
3
2
(a)
6
21a
21b
3
2
(b)
6

【図6】


31
33
32
3
2
1
8
7
6

【図7】


105
103a
104
103
102
(a)
107
108
106
101
105
103a
104
103
102
(b)
109
101